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CLUTCH ASSEMBLY

[0001] The present invention is directed to a clutch assembly having a clutch, to engage the clutch, a pressure plate being moved axially against the force of the lining springiness; having a lever plate, supported in the peripheral region, which transmits the force applied by a clutch-release system to a release bearing, to the pressure plate with leverage; and having a clutch actuator, whose actuating force, which is amplified by the force of a linear compensating spring, acts on the clutch-release system.

[0002] In the case of clutches used in motor vehicles, the clutch pedal can be eliminated when the clutch is driven by an actuator. This actuator can be electrical, hydraulic or pneumatic, an electromechanical clutch actuation being preferred.

[0003] When automatically operated clutch systems having a clutch actuator are used, it turns out to be beneficial to utilize the actuating force to engage the clutch. In this context, it has been shown that the force characteristic of a engaged clutch is essentially characterized by the characteristic of the lining springiness. When compensation is carried out by using a linear coil spring in the clutch actuator, the actuating force can only be divided approximately in half, a change in the direction of force being noted.

[0004] The object of the present invention is, therefore, to provide a clutch assembly which will enable the clutch actuating force to be adapted to a linear compensating spring while entailing little expenditure.

[0005] This objective is achieved for a clutch assembly of the type mentioned at the outset by a spring force which acts in the direction of the force of the lining springiness on the lever plate and whose magnitude is adapted to the magnitude of the force of the linear compensating spring.

[0006] The advantages attained by the present invention lie in particular in that the loading of the clutch actuator is able to be varied by the action of an additional spring force

and thus better adapted to a linear compensating spring. In this context, the lever system design of the closed clutch requires that the release bearing apply a greater load over the entire range of motion. This force-travel characteristic may then be advantageously compensated by the clutch actuator using a simple linear coil spring.

[0007] In accordance with one preferred embodiment of the present invention, in order to apply the spring force, the lever plate is designed as a lever diaphragm-spring system. Thus, no further constructional outlay is required for applying the spring force. Moreover, the force characteristic of a diaphragm spring is able to be adapted very effectively to the force characteristic of a linear compensating spring.

[0008] One preferred refinement of the present invention provides for the bearing surface of the pressure plate to be equipped with an adjusting ring to compensate for wear. Without compensating for wear in this manner, clutch-lining wear would alter the position of the lever plate and, respectively, of the lever diaphragm-spring system and thus change the force characteristics undesirably.

[0009] Another advantageous possibility for compensating for wear is provided by an adjusting ring that acts on the peripheral region of the lever plate. A cover stop is then preferably assigned to the radially inner region of the lever plate.

[0010] The combined action of an adjusting ring acting on the peripheral region of the lever plate and of a cover stop, leads, in response to actuation of the adjusting ring, to a changed lever plate position. Disadvantageous variations in the force characteristics are then preferably prevented by assigning an adjusting diaphragm spring to the lever plate to apply the spring force. An adjusting diaphragm spring of this kind may then be positioned in such a way that the spring force does not change in response to changes in the lever plate position.

[0011] In accordance with one first advantageous positioning possibility, the adjusting diaphragm spring is mounted on the outside of the lever plate. In this context, it is especially beneficial when the adjusting diaphragm spring is held in the peripheral region by a cover attachment and, in the radially inner region, by a lever-plate attachment.

[0012] In accordance with a second advantageous positioning possibility, the adjusting diaphragm spring is mounted on the inner side of the lever plate. In this context, it is especially beneficial when the adjusting diaphragm spring is held in the peripheral region by a cover attachment and rests in the radially inner region against the lever plate.

[0013] In one especially preferred embodiment of the present invention, the magnitude of the spring force acting on the lever plate is adapted to the magnitude of the force of the linear compensating spring in such a way that positive actuating forces are produced at the clutch actuator. It is beneficial in this context that only one direction of force occurs at the release bearing. This enables a conventional release bearing and a simple cap bearing to be used. Assembly and disassembly operations are thereby simplified. Moreover, advantages are derived for the clutch actuator design since only one direction of force is required at the lifting gear. This benefits the design of the transmission components and mounts and, under certain circumstances, may prevent actuator backlash.

[0014] In accordance with another embodiment of the present invention, the magnitude of the spring force acting on the lever plate is adapted to the magnitude of the force of the compensating spring in such a way that a large range of motion with minimal actuating forces results at the clutch actuator. In this case, to achieve minimal actuating forces, a change in the direction of the actuating forces is accepted.

[0015] Other advantages and advantageous embodiments are derived from the dependent claims and from the drawings described in the following. Specifically shown in:

[0016] Figure 1 is a first clutch having a lever spring-diaphragm system in a greatly simplified schematic representation;

[0017] Figure 2 is a clutch actuator having a subordinate clutch-release system for actuating the clutch illustrated in Figure 1, in a greatly simplified schematic representation;

[0018] Figures 3 and 4 is the lever diaphragm-spring system of the clutch illustrated in Figure 1 in a partial plan view and,

respectively, in cross section;

- [0019] Figure 5 is a diagram showing the characteristic curve of the actuating force, compensating force and actuator load over the actuator travel for a conventional clutch assembly;
- [0020] Figure 6 is a diagram showing the characteristic curve of the actuating force, compensating force and actuator load over the actuator travel for a clutch assembly according to the present invention;
- [0021] Figure 7 is a second clutch having a lever spring-diaphragm system and compensation for wear at the pressure plate, in a greatly simplified schematic representation;
- [0022] Figures 8 and 9 is a third clutch having a lever plate and an adjusting diaphragm spring on the outside of the lever plate, in a new condition and, respectively, after compensating for wear;
- [0023] Figures 10 and 11 is a fourth clutch having a lever plate and an adjusting diaphragm spring on the inner side of the lever plate, in a new condition and, respectively, after compensating for wear; and
- [0024] Figures 12 through 17 are diagrams clarifying how the properties of the actuator loading are able to be influenced by tuning the force characteristics of the lining springiness, the lever diaphragm-spring system, and of the compensating spring in the clutch actuator.
- [0025] In a greatly simplified schematic representation, Figure 1 shows a section through

the upper part of a clutch denoted, as a whole, by K1. Discernible, in succession, inside housing 1 of clutch K1 in a pulled-apart view are a flywheel 2, a first clutch lining 3, a clutch hub 4, a lining springiness indicated by a wavy line 5, a second clutch lining 6, a pressure plate 7 together with its bearing surface 70, and a lever plate 8. The cover of housing 1 which follows cover plate 8 is denoted by 9. Flywheel 2 is connected to the crankshaft (not shown in detail) of a driving engine, while clutch hub 4 is mounted on the input shaft (likewise not shown in detail) of the transmission. In response to engagement of the clutch, pressure plate 7 is shifted axially toward flywheel 2, until, in the engaged state, lining springiness 5 is compressed, and first clutch lining 3 is pressed against flywheel 2. The force of lining springiness 5 acting in the axial direction is indicated in Figure 1 by an arrow and designated by  $F_{KS}$ , index  $KS$  providing an indication of the clutch disk. The pressure-plate travel during clutch engagement is likewise indicated in Figure 1 by an arrow and denoted by  $r$ .

[0026] Clutch K1 is actuated by a clutch actuator, denoted as a whole by 13 in Figure 2, in which are situated, in sequence, a servomotor 130, an intermediate gear 131 and a lifting gear 132. Lifting gear 132 is, for example, a spindle drive. Also belonging to clutch actuator 13 is a linear compensating spring 14, whose spring force is indicated by an arrow and is denoted by  $F_{KO}$ . This spring force  $F_{KO}$  of linear compensating spring 14 amplifies the actuating force produced by lifting gear 132, the resulting actuating force being indicated by an arrow and denoted by  $F_S$  in Figure 2.

[0027] It is discernible that actuating force  $F_S$  is transmitted via a clutch-release system 12, which, for example, is a so-called central release mechanism, to a release bearing 11, the force acting on release bearing 11 in Figure 2 being indicated by an arrow and denoted by  $F_A$ . It is also discernible that release bearing 11, for its part, acts on the central area of lever plate 8, which, in Figure 2, in order to clarify this operation, projects slightly out of clutch K1, which is merely shown schematically.

[0028] In Figure 1, the action of release bearing 11 on lever plate 8 is indicated by an arrow  $F_A$  running in the axial direction. Lever plate 8, which is supported in the peripheral region in a circumferential groove (not shown in detail) of housing 1, transmits force  $F_A$  with leverage to bearing surface 70 of pressure plate 7. On the other hand, lever plate 8, which is shown in greater detail in Figures 3 and 4, is designed as a lever diaphragm-spring system,

which is installed in the preloaded state in clutch K1, this preloading being indicated in Figure 1 by a curved arrow (not more closely designated). In accordance with Figure 3, lever plate 8 is provided with a multiplicity of holes 81 and radial slots 82, so that they may also be regarded as a sum of radially aligned, one-armed levers which are disposed side-by-side in the circumferential direction. In the cross section in accordance with Figure 4, the effective diaphragm spring region of lever plate 8 is denoted by 83, while the pure lever region is denoted by 84.

[0029] In Figure 1, the spring force produced by the spring properties of lever plate 8 is indicated by an arrow and denoted by  $F_{TF}$ . It is discernible that spring force  $F_{TF}$  acts at the level of bearing surface 70 of pressure plate 7 in the same direction as force  $F_{KS}$  of lining springiness 5. Thus, the effect of spring force  $F_{TF}$  of lever plate 8 designed as a lever diaphragm-spring system is that release bearing 11 (compare Figure 2) must apply a greater load over the entire range of motion. Thus, between force  $F_{KS}$  of lining springiness 5 of spring force  $F_{TF}$  of lever plate 8 and force  $F_A$  acting on release bearing 11 (compare Figure 2), the following relationship is derived

$$O = F_{KS} + F_{TF} - i \cdot F_A,$$

the lever ratio determined by the dimensions of lever plate 8 being denoted by  $i$ .

[0030] Spring force  $F_{TF}$  applied by the diaphragm spring action of lever plate 8 is adapted to force  $F_{KO}$  of compensating spring 14 (compare Figure 2), this adaptation being clarified with reference to the diagrams illustrated in Figures 5 and 6. In these two diagrams, the characteristic curve of the actuating force denoted by I, the characteristic curve of the actuator load denoted by II, and the characteristic curve of the compensating force, designated by III and shown as a broken line, are plotted over actuator travel  $s$ , forces  $F$  being indicated in N, and actuator travel  $s$  being indicated in mm.

[0031] The diagram in accordance with Figure 5 shows the influences of a linear compensating spring in a conventional clutch assembly, namely how it effects a change in the direction of force in the characteristic curve of actuator load II. In contrast, the diagram in accordance with Figure 6, given a same compensation, shows a changed characteristic curve of actuating force I and of actuator load II, this change being caused by spring force  $F_{TF}$  of lever plate 8 designed as a lever diaphragm-spring system (compare Figure 1). The greater

actuating forces produced by spring force  $F_{TF}$  are adapted to the compensating forces in such a way that no change in the action of force is to be noted in the entire characteristic curve II of the actuating force. Thus, the adaptation of spring force  $F_{TF}$  (compare Figure 1) to force  $F_{KO}$  of linear compensating spring 14 effects positive actuating forces  $F_S$  of clutch actuator 13 (compare Figure 2).

[0032] Clutch-lining wear would alter the position of the lever diaphragm-spring system. The consequence would be a rapid change in the force characteristics. The measures proposed in Figures 7 through 11 indicate various approaches for overcoming this problem.

[0033] Clutch K2 depicted in Figure 7 substantially corresponds to clutch K1 in accordance with Figure 1. Here, however, bearing surface 70 of pressure plate 7 is equipped with an adjusting ring 71 for compensating for wear. This adjusting ring 71 is designed as a ramp ring, which moves to the right when rotated axially and is thus able to compensate for wear on clutch linings 3 and 6. Thus, by compensating for wear with the aid of adjusting ring 71, it is possible to avoid any change in the position of lever plate 8 designed as a lever diaphragm-spring system, i.e., any change in the force characteristics is avoided.

[0034] Figures 8 and 9 show a clutch K3 which corresponds substantially to clutch K1 in accordance with Figure 1. However, the lever plate denoted here by 85 does not feature any spring characteristics or, at most, only negligible spring characteristics, so that spring force  $F_{TF}$  (compare Figure 1) must be applied by an adjusting diaphragm spring 89. This adjusting diaphragm spring 89, whose spring action is indicated by a curved arrow (not shown in greater detail), is located on the outside of lever plate 85. Adjusting diaphragm spring 89 is held in the peripheral region by an attachment 91 of the cover denoted here by 90, while the radially inner region is held by an attachment 86 of lever plate 85. To compensate for wear, an adjusting ring 87, which acts on the peripheral region of lever plate 85, is provided on cover 90. Adjusting ring 87 is a ramp ring that is customary in clutch manufacture. A cover stop 92, which limits the motion of lever plate 85 during the adjustment, is assigned to adjusting ring 87.

[0035] Figure 8 shows clutch K3 in a new condition, while Figure 9 shows clutch K3 after clutch linings 3 and 6 have been subject to wear and adjusting ring 87 has been actuated

accordingly. It is discernible that the position of lever plate 85 changes perceptibly in response to actuation of adjusting ring 87 and, however, that the position of adjusting diaphragm spring 89 remains the same. Thus, in clutch K3, a compensation for wear does not lead to any change in the force characteristics.

[0036] Figures 10 and 11 show a clutch K4 which corresponds substantially to clutch K1 in accordance with Figure 1. However, lever plate denoted here by 88 does not feature any spring characteristics or, at most, only negligible spring characteristics, so that, here as well, spring force  $F_{TF}$  (compare Figure 1) must be applied by an adjusting diaphragm spring 89. This adjusting diaphragm spring 89, whose spring action is indicated by a curved arrow (not shown in greater detail), is located on the inner side of lever plate 88. Adjusting diaphragm spring 89 is held in the peripheral region by an attachment 96 of the cover denoted here by 95, while the radially inner region rests against lever plate 88. Cover attachment 96 is subdivided in the circumferential direction into segments, the individual segments passing through corresponding cut-outs in lever plate 88. Here as well, to compensate for wear, an adjusting ring 87, which acts on the peripheral region of lever plate 88, is provided on cover 95. A cover stop 97, which limits the motion of lever plate 88 during the adjustment, is assigned to adjusting ring 87.

[0037] Figure 10 shows clutch K4 in a new condition, while Figure 11 shows clutch K4 after clutch linings 3 and 6 have been subject to wear and adjusting ring 87 has been actuated accordingly. It is discernible that the position of lever plate 88 changes perceptibly in response to actuation of adjusting ring 87 and, however, that the position of adjusting diaphragm spring 89 remains the same. Thus, in clutch K4, a compensation for wear does not lead to any change in the force characteristics.

[0038] In clutches K1, K2, K3 and K4 clarified with reference to Figures 1, 7, 8 and 9, as well as 10 and 11, the greater clutch-release forces produced by additional spring force  $F_{TF}$  (compare Figure 1) may be reinforced by a clutch-release system that is fixed to the cover. This makes it possible to avoid greater loading of the crankshaft bearing.

[0039] On the basis of diagrams, Figures 12 through 17 show how the properties of the actuator loading are able to be influenced by tuning the force characteristics of the lining

springiness, the lever diaphragm-spring system, and of the compensating spring. In the diagrams in accordance with Figures 12, 14 and 16, the characteristic curve of the force of the lining springiness denoted by IV, the characteristic curve of the force of the lever diaphragm-spring system denoted by V, and the characteristic curve of the actuating force denoted by VI are plotted, respectively, over pressure-plate travel  $r$  (compare Figure 1), forces  $F$  being indicated in N, and the pressure-plate travel being indicated in millimeters. In the diagrams in accordance with Figures 13, 15 and 17, the characteristic curve of the actuating force denoted by I, the characteristic curve of the actuator load denoted by II, and the characteristic curve of the compensating force denoted by III are plotted, respectively, over actuator travel  $s$ , forces  $F$  being indicated in N, and actuator travel being indicated in millimeters.

[0040] The diagrams illustrated in Figures 12 and 13 show that a relatively high spring force  $F_{TF}$  of lever plate 8 designed as a lever spring-diaphragm system (compare Figure 1) and spring force  $F_{KO}$  of compensating spring 14 (compare Figure 2) produce positive actuating forces  $F_S$  at clutch actuator 13.

[0041] The diagrams depicted in Figures 14 and 15 show that, given an equivalent spring force  $F_{KO}$  of compensating spring 14, a reduced spring force  $F_{TF}$  effects a change in the direction of actuating force  $F_S$ .

[0042] The diagrams illustrated in Figures 16 and 17 show that a relatively high spring force  $F_{TF}$  and a higher spring force  $F_{KO}$  of a more powerful compensating spring 14 effect a large range of motion with minimized actuating forces  $F_S$  at clutch actuator 13.

[0043] The relationships illustrated in Figures 12 through 17 for clutch K1 (compare Figure 1) are also applicable to clutches K2, K3 and K4 in accordance with Figures 7, 8 and 9, as well as 10 and 11.

[0044] The claims filed with the application are proposed formulations and do not prejudice the attainment of further patent protection. The applicant reserves the right to claim still other combinations of features that, so far, have only been disclosed in the specification and/or the drawings.

[0045] The antecedents used in the dependent claims refer, by the features of the respective dependent claim, to a further embodiment of the subject matter of the main claim; they are not to be understood as renouncing attainment of an independent protection of subject matter for the combinations of features of the dependent claims having the main claim as antecedent reference.

[0046] Since, in view of the related art on the priority date, the subject matters of the dependent claims may form separate and independent inventions, the applicant reserves the right to make them the subject matter of independent claims or of divisional applications. In addition, they may also include independent inventions, whose creation is independent of the subject matters of the preceding dependent claims.

[0047] The exemplary embodiments are not to be understood as limiting the scope of the invention. Rather, within the framework of the present disclosure, numerous revisions and modifications are possible, in particular such variants, elements and combinations and/or materials, which, for example, by combining or altering individual features or elements or method steps described in connection with the general description and specific embodiments, as well as the claims, and contained in the drawings, may be inferred by one skilled in the art with regard to achieving the objective, and lead, through combinable features, to a new subject matter or to new method steps or sequences of method steps, also to the extent that they relate to manufacturing, testing, and operating methods.